The Design of Post-tensioned Concrete Box Girders to Eurocodes

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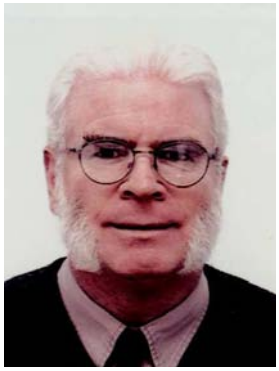

Angus Low, born 1947, graduated from Cambridge University and joined Arup in London in 1968, where he has since spent most of his career designing bridges. He is interested in understanding design at a fundamental level, which helps him to find simpler solutions.

Summary

The effect of the new Eurocodes on the design of prestressed concrete box-girder bridges is investigated. The Moment/Stress plot is introduced to display the combined effect of many different clauses. Its use together with economic data from current projects leads to a surprising result. Even for quite long span structures it will be more economic to use reinforced concrete instead of prestressed concrete as currently used. The subject is discussed.

Keywords: Prestressed concrete. Post-tensioned concrete. Partial prestressing. Eurocodes. Long-span concrete bridges. Moment/Stress plot.

1. Introduction

This paper describes an unexpected consequence of the adoption of Eurocodes. It is likely that reinforced concrete will be used for much longer spans than previously, and the use of post-tensioning in bridges will decrease significantly.

The practice of prestressing and post-tensioning concrete structures was developed by Eugene Freyssinet during the 1930s and 1940s. He set out the theory and practice of prestressed concrete design [1]. A key feature was that the act of stressing a concrete member changed its nature, with many benefits, and the calculations needed to design it and demonstrate its adequacy are different from those needed for reinforced concrete sections. Specifically the adequacy of reinforced concrete is demonstrated with a "cracked analysis" in which it is assumed that concrete is always cracked when it is in tension. The adequacy of prestressed concrete is demonstrated with an uncracked analysis. It is required that the amount of tension stress in a prestressed member is limited to a level at which it does not significantly affect the behaviour of the member. It is usually specified that a cracked analysis under ultimate loads is also performed.

Cracked and uncracked analysis methods are very different. Structural engineers tend to visualise prestressed concrete and reinforced concrete as being different materials, and this is the way they have been treated in design codes. Even the introduction of "partial prestressing" during the 1960s still used an uncracked analysis to limit the amount of tension and did not significantly change the idea of two different materials.

Since the introduction of prestressed concrete it has been used universally for all medium and long-span concrete bridges. This means almost all concrete spans greater than about 25m. It is difficult to think of any recent long span reinforced concrete beam bridge. Going back before the era of conventional prestressing, the Waterloo Bridge in London was completed in 1945 and has repeating spans of 71m in reinforced concrete, with varying depth box-girders. As an early form of prestressing some of the bars were heated to apply a prestrain to them. As far as the author knows it has behaved satisfactorily. The October 6th Bridge in Cairo includes several kilometres of structure. The author has heard that it has a reinforced concrete box girder span of 141m. Whether this is true or not it does not alter the fact that there is no current orthodoxy for designing and building long span reinforced concrete bridges.

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